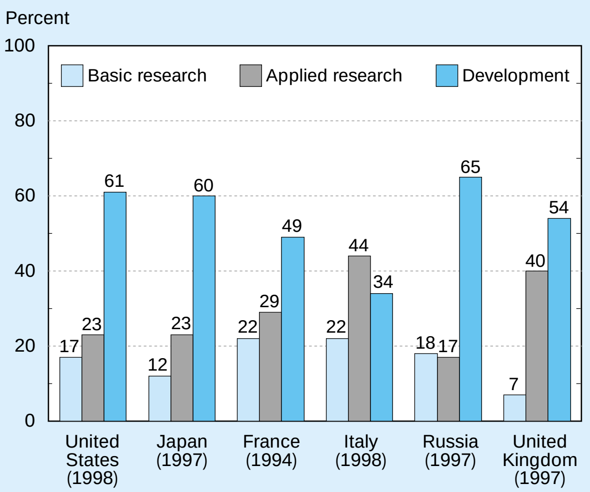
Character of R&D Effort

Not all of the G-8 countries categorize their R&D expenditures into character of work classifications (that is, basic research, applied research, or development), and for several countries that do utilize this taxonomy, the data are somewhat dated (OECD 1999c). Nonetheless, where these data exist, they are indicative of the relative emphasis that a country places on supporting fundamental scientific activities—the seed corn of economic growth and technological advancement.

The United States expends about 17 percent of its R&D on activities that performers classify as basic research. (See figure 2-33.) Much of this research is funded by the Federal Government and is performed in the academic sector. The largest share of this basic research effort is in support of the life sciences.

Basic research accounts for a similar portion (18 percent) of the R&D total in the Russian Federation. In comparison with U.S. patterns, however, a considerably greater share is for engineering research activities. In Japan, a comparatively smaller amount (12 percent) of the national R&D performance effort is for basic research, but as in Russia engineering fields receive the largest share of these funds. Conversely, basic research accounts for more than 20 percent of total R&D performance reported in Italy, France, and Germany. Furthermore, basic research would likely account for a similar share of the United Kingdom's R&D were these data available and published for the academic and nonprofit sectors—traditional locations for basic research activities. Except in Italy (where applied research was dominant), development activities accounted for the largest share of national totals, with most of the experimental development work underway in their respective industrial sectors.

Figure 2-33.
Distribution of R&D by character of work, in selected G-8 countries



NOTES: The character of work for 6 percent of Japan's R&D is unknown. The U.K splits are for industrial and government performers only. R&D character of work data for the higher education and nonprofit sectors (21 percent of the national total) are unavailable. For Germany, 21 percent of its 1993 R&D was basic research; the rest was undistributed. Canada does not report any of these data. Because of rounding, detail may not sum to totals.

SOURCES: Organization for Economic Co-operation and Development (OECD). 1999c. *Basic Science and Technology Statistics: 1998* (on diskette). Paris: OECD; Center for Science Research and Statistics (CSRS) 1999. *Russian Science and Technology at a Glance: 1998*. Moscow: CSRS.

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International Comparisons of Government R&D Priorities

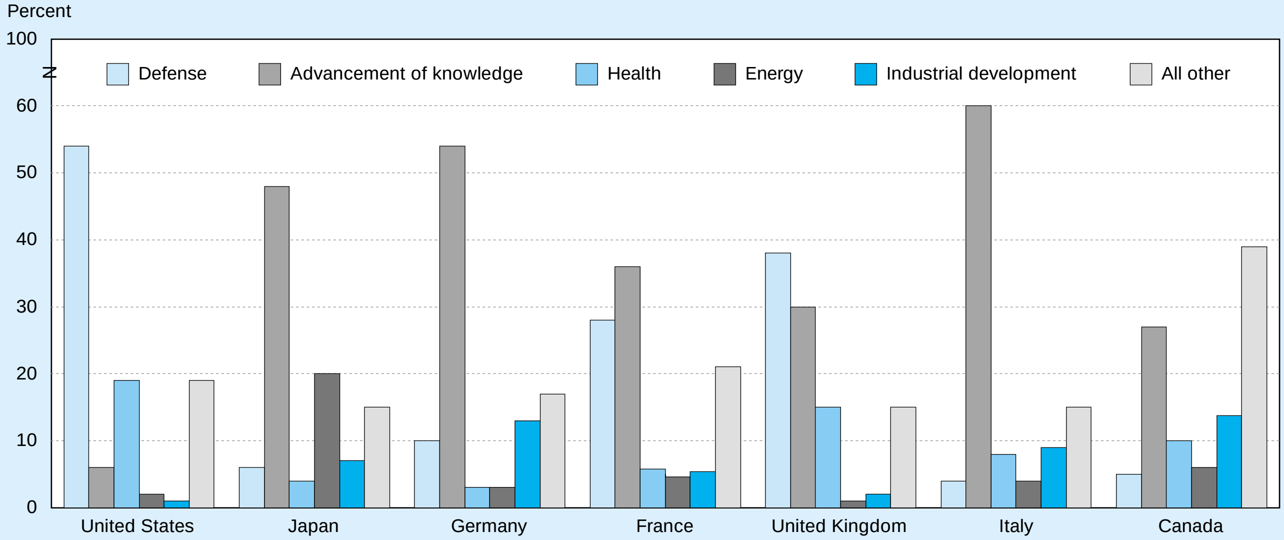
The downturn in R&D growth within OECD countries has been disproportionately caused by flat or declining government funding of R&D since the late 1980s. These developments reflect and add to worldwide R&D landscape changes that present a variety of new challenges and opportunities. The following sections highlight government R&D funding priorities in several of the larger R&D-performing nations, summarize broad policy trends, and detail indirect support for research that governments offer their domestic industries through the tax code.

Funding Priorities by National Objective

A breakdown of public expenditures by major socioeconomic objectives provides insight into governmental priorities, which differ considerably across countries.[50] In the United States, 54 percent of the government's $74 billion R&D investment during 1998 was devoted to national defense. This share compares with the 38 percent defense share in the United Kingdom (of an $9 billion government total); 28 percent in France (of $13 billion); and 10 percent or less each in Germany, Italy, Canada, and Japan. (See figure 2-34 and appendix table 2-66.) These recent figures represent substantial cutbacks in defense R&D in the United States, the United Kingdom, and France—where defense accounted for 63 percent, 44 percent, and 40 percent of government R&D funding, respectively, in 1990. However, defense-related R&D also seems particularly difficult to account for in many countries' national statistics. (See sidebar, "Accounting for Defense R&D: Gap Between Performer- and Source-Reported Expenditures.")

[50]Data on the socioeconomic objectives of R&D funding are rarely obtained by special surveys; they are generally extracted in some way from national budgets. Because those budgets already have their own methodology and terminology, these R&D funding data are subject to comparability constraints not placed on other types of international R&D data sets. Notably, although each country adheres to the same criteria for distributing their R&D by objective—as outlined in OECD's Frascati Manual (OECD 1994)—the actual classification may differ among countries because of differences in the primary objective of the various funding agents. Note also that these data reflect government R&D funds only, which account for widely divergent shares and absolute amounts of each country's R&D total.

Figure 2-34.
Government R&D support, by country and socioeconomic objective: 1997–98



NOTES: R&D is classified according to its primary government objective, although it may support any number of complementary goals. For example, defense R&D with commercial spinoffs is classified as supporting defense, not industrial development. R&D for the advancement of knowledge is not equivalent to basic research.

See appendix table 2-66. *Science & Engineering Indicators – 2000*

International Nondefense Functions

Japanese, German, and Italian government R&D appropriations in 1997 were invested relatively heavily (48 percent or more of the $18 billion total for Japan, 54 percent of Germany's $16 billion total, 60 percent of the $6 billion total in Italy) in advancement of knowledge—that is, combined support for advancement of research and general university funds (GUF). Indeed, the GUF component of advancement of knowledge—for which there is no comparable counterpart in the United States—represents the largest part of government R&D expenditure in most OECD countries.[51]

[51]In the United States, "advancement of knowledge" is a budgetary category for research unrelated to a specific national objective. Furthermore, whereas GUF is reported separately for Japan, Canada, and European countries, the United States does not have an equivalent GUF category: Funds to the university sector are distributed to address the objectives of the Federal agencies that provide the R&D funds. Nor is GUF equivalent to basic research. The treatment of GUF is one of the major areas of difficulty in making international R&D comparisons. In many countries, governments support academic research primarily through large block grants that are used at the discretion of each individual higher education institution to cover administrative, teaching, and research costs. Only the R&D component of GUF is included in national R&D statistics, but problems arise in identifying the amount of the R&D component and the objective of the research.

Government GUF support is in addition to support provided in the form of earmarked, directed, or project-specific grants and contracts (funds for which can be assigned to specific socioeconomic categories). In the United States, the Federal Government (although not necessarily state governments) is much more directly involved in choosing which academic research projects are supported than national governments in Europe and elsewhere. Thus, these socioeconomic data are indicative not only of relative international funding priorities but also of funding mechanisms and philosophies regarding the best methods for financing research. For 1997, the GUF portion of total national governmental R&D support was 47 percent in Italy, about 38 percent in Japan and Germany, and just under 20 percent in the United Kingdom, Canada, and France.

The emphasis on health-related research is much more pronounced in the United States than in other countries. This emphasis is especially notable in the support of life sciences in academic and similar institutions. In 1998, the U.S. government devoted 19 percent of its R&D investment to health-related R&D, making such activities second only to defense. (Direct comparisons between health and defense R&D are complicated because most of the health-related R&D is research, whereas about 90 percent of defense R&D is development.) By comparison, health R&D support ranges between 9 and 15 percent of total spending in the governmental R&D budgets of the United Kingdom, Italy, and Canada.

Different activities were emphasized in other countries' governmental R&D support statistics. Japan committed 20 percent of governmental R&D support to energy-related activities, reflecting the country's historical concern about its high dependence on foreign sources of energy. In Canada, 12 percent of the government's $3 billion in R&D funding was directed toward agriculture. Space R&D received considerable support in the United States and France (11 percent of the total in each country), whereas industrial development accounted for 9 percent or more of governmental R&D funding in Germany, Italy, and Canada. Industrial development programs accounted for 7 percent of the Japanese total but just 0.5 percent of U.S. R&D. The latter figure is understated relative to other countries as a result of data compilation differences.

Accounting for Defense R&D: Gap Between Performer- and Source-Reported Expenditures

In many OECD countries, including the United States, total government R&D support figures reported by government agencies differ substantially from those reported by performers of R&D work. Consistent with international guidance and standards (OECD 1994), however, most countries' national R&D expenditure totals and time series are based primarily on data reported by performers. This convention is preferred because performers are in the best position to indicate how much they spent in the actual conduct of R&D in a given year and to identify the source of their funds. Although there are many reasons to expect funding and performing series to differ—such as different bases used for reporting government obligations (fiscal year) and performance expenditures (calendar year)—the gap between the two R&D series has widened during the past several years. Additionally, the divergence in the series is most pronounced in countries with relatively large defense R&D expenditures.

For the United States, the reporting gap has become particularly acute over the past several years. In the mid-1980s, performer-reported Federal R&D exceeded Federal reports by $3 to $4 billion annually—5 to 10 percent of the government total. This pattern reversed itself toward the end of the decade; in 1989 government-reported R&D total exceeded performer reports by $1 billion. The gap has since grown to about $5 billion. In other words, about 7 percent of the government total in the late 1990s is unaccounted for in performer surveys. (See figure 2-35.)

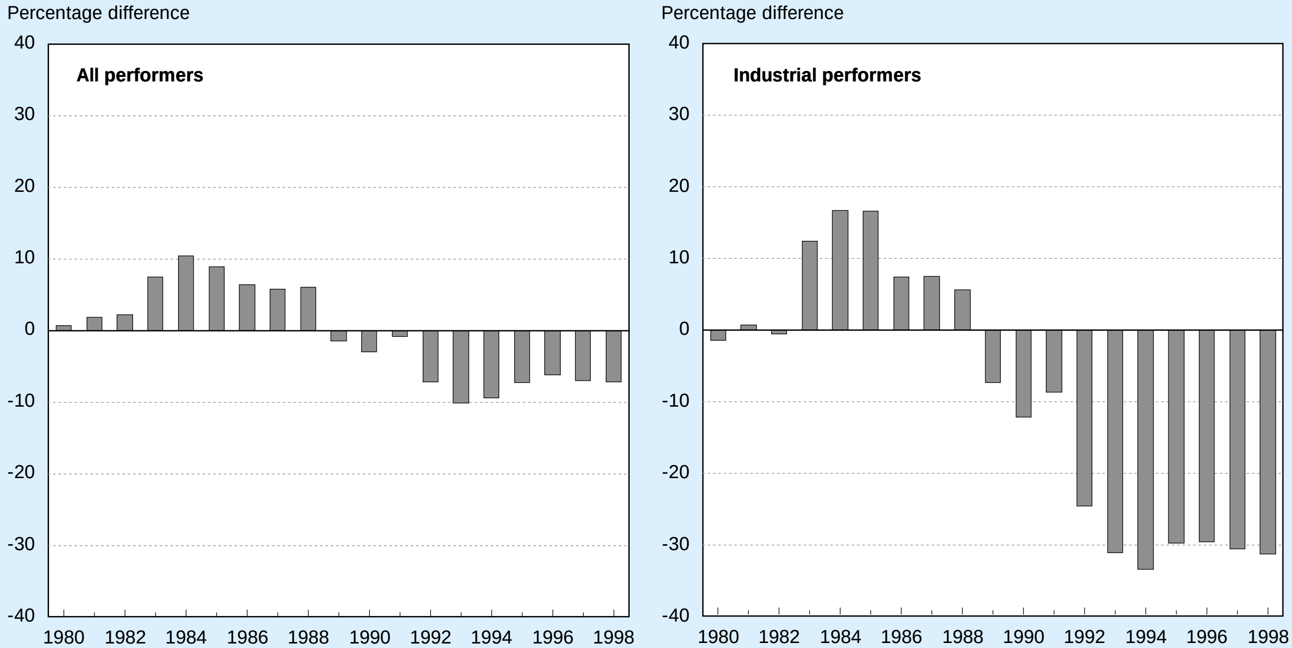
The difference in Federal R&D totals is primarily in DOD development funding of industry (primarily aircraft and missile firms). For 1997, Federal agencies reported $31.4 billion in total R&D obligations provided to industrial performers, compared with an estimated $21.8 billion in Federal funding reported by industrial performers. (DOD reports industry R&D funding of $24.2 billion, whereas industry reports using $12.6 billion of DOD's R&D funds.) Overall, industry-wide estimates equate to a 31 percent paper "loss" of Federally reported R&D support. (See figure 2-35.)

To investigate causal factors for the reporting gap, NSF—working with DOD contract-specific data—conducted on-site interviews with carefully selected companies that perform Federal R&D for DOD. Companies were asked about their R&D activities, data collection and reporting methods, and subcontracting practices. They also were asked to volunteer information about other factors that might influence the growing reporting difference. On the basis of these interviews and supplemental data analyses, the following factors appear to contribute most to the observed data gap.

Shifts in the composition of R&D, test, and evaluation (RDT&E) contracts during the past 10 years—since the end of the Cold War—introduced numerous changes in DOD's budgeting choices. Between 1991 (the last year that Federal funding and performing totals were relatively close) and 1998, DOD procurement spending (in inflation-adjusted terms) fell by 50 percent, whereas RDT&E spending declined by a relatively modest 7 percent. Concurrently, the proportion of DOD's RDT&E funding of traditional R&D program activities such as missile and space systems, tanks, ships, and other weapons systems has decreased; funding of more generalized technical, analytical and professional service contracts has increased. This trend has been accompanied by the emergence of new, nontraditional contractors (including large communication carriers and small high-technology firms) and firms specializing in program support activities within the DOD-funded R&D-performing industrial sector. Consequently, an increasing share of what DOD now funds, and therefore reports as R&D, is not necessarily perceived as R&D by industry performers. Industry representatives also mentioned significant changes in DOD's overall budget environment whereby RDT&E funds are now used to update military equipment under an emerging procurement management concept called "repeated R&D," whereby new technology is being incorporated on an ongoing basis into military systems. The effect is that RDT&E appropriations are now funding activities that could have been considered production 10 years ago. In short, there has been a change in what constitutes the R&D activity that is not similarly captured from Federal and industry respondents.

As a result of major changes in DOD's efforts to streamline its procurement environment and practices, the use of large, flexible, multiyear, multi-agency, indefinite order-type contract vehicles has become increasingly common. These contracts, which can be used

Figure 2-35.
Difference in U.S. performer-reported versus agency-reported Federal R&D



NOTE: Difference is defined as the percentage of federally reported R&D.

See appendix table 2-59.

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by nearly every Federal agency, significantly reduce administrative and procurement actions needed to acquire services and technical support from previously selected contractors. They also have very high funding "ceilings" that allow government agencies to order tasks as needed. These contract vehicle characteristics tend to hide the ultimate funding source for particular activities and confuse the original "color of money" (i.e., the nature of the originating appropriation accounts). The effects of these procurement reforms were widespread in 1992 and 1993.

Finally, the consolidation of the defense and aerospace R&D business (see figure 4-10 in NSB 1998), as well as other corporate mergers and acquisitions, has considerably complicated industries' tracking of defense-related R&D. Few firms (especially extremely large, diversified companies) maintain award-specific data on R&D contracts for their many subsidiaries. Consequently, R&D-intensive activities of acquired firms may not be visible at corporate headquarters responding to national R&D surveys. This reporting problem is magnified with recent growth in R&D outsourcing. In such circumstances, the subcontracted ("routine technical service") activity often is performed by companies with only scant knowledge of the original funding source and perhaps even less knowledge on the overall DOD R&D objective to which their work is contributing.

The relative importance of these considerations in quantifying these data differences is unknown. Clearly, however, a variety of factors affect the collection of consistently reported R&D data from performers and funders. A similar mismatching of Federal R&D to academia as reported by universities and Federal agencies is now appearing in the data series. In this instance, however, totals reported by universities exceed those reported by Federal respondents. Indeed, other countries also have difficulty tracking and matching performer and source data (see NSB 1998)—indicative of the transitional changes affecting the S&E enterprise globally.

International Comparisons of Government R&D Tax Policies

In most OECD countries, government not only provides direct financial support for R&D activities but also uses indirect mechanisms such as tax relief to promote national investment in science and technology. Indeed, tax treatment of R&D in OECD countries is broadly similar, with some variations in the use of R&D tax credits (OECD 1996, 1999a). The following are the main features of the R&D tax instruments:

- Almost all countries (including the United States) allow industry R&D expenditures to be 100 percent deducted from taxable income in the year they are incurred.
- In most countries, R&D expenditures can by carried forward or deducted for 3 to 10 years. (In the United States, there is a 3-year carry-forward on R&D expenditures and a 15-year carry-forward on R&D capital assets.)
- About half the countries (including the United States; see "U.S. Federal and State R&D Tax Credits") provide some type of additional R&D tax credit or incentive, with a trend toward using incremental credits. A few countries also use more targeted approaches, such as those favoring basic research.
- Several countries have special provisions that favor R&D in small and medium-size enterprises. (In the United States, credit provisions do little to help small start-up firms, but more direct Federal R&D support is provided through grants to small firms. See "Federal Support for Small Business R&D.")
- A growing number of R&D tax incentives are being offered at the subnational (provincial and state) levels, including in the United States (see "U.S. Federal and State R&D Tax Credits").[52]

International Public- and Private-Sector R&D and Technology Cooperation

Particularly in light of recent advances in information and communication technologies, international boundaries have become considerably less important in structuring the conduct of R&D and the use of research collaborations. Indicators of R&D globalization illustrate these R&D landscape changes for each of the R&D-performing sectors. Growth in international academic research collaboration is exhibited by the substantial increase in international co-authorship trends. (See chapter 6.) Extensive global growth in public-sector and industrial R&D activities is detailed below.

Public-Sector Collaboration

The rapid rise in international cooperation has spawned activities that now account more than 10 percent of government R&D expenditures in some countries. A significant share of these international efforts results from collaboration in scientific research involving extremely large "megascience" projects. Such developments reflect scientific and budgetary realities: Excellent science is not the domain of any single country, and many scientific problems involve major instrumentation and facility costs that appear much more affordable when cost-sharing arrangements are in place. Additionally, some scientific problems are so complex and geographically expansive that they simply require an international effort.[53] As a result of these concerns and issues, an increasing number of S&T-related international agreements have been forged between the U.S. government and its foreign counterparts during the past decade.

U.S. Government's Use of International S&T Agreements

International governmental collaboration in S&T and R&D activities appears to be a growing phenomenon. There are few sources of systematic information on government-to-government cooperative activities, however. A report by the U.S. General Accounting Office (GAO 1999) provides a snapshot of seven Federal agencies' international S&T agreements that were active during FY 1997. The GAO accounting is only for official, formal agreements and therefore provides a lower-bound estimate of the number of governmental global S&T collaborations. Most international cooperation is continuous and ongoing and takes place outside the framework of official, formal agreements. Nonetheless, the GAO study found that these seven agencies—DOE, NASA, NIH, NIST, the National Oceanographic and Atmospheric Administration (NOAA), NSF, and the Department of State—participated in 575 such agreements with 57 countries, 8 international organizations, and 10 groups of organizations or countries. Fifty-four of these agreements were broad-based bilateral arrangements between the U.S. government and governments of foreign countries—commonly referred to as "umbrella" or "framework" agreements. The remaining 521 agreements were bilateral agreements between research agencies and their counterparts in foreign governments and international organizations (381) or multilateral agreements (140) to conduct international cooperative research, provide technical support, or share data or equipment.

Generally, such agreements—which are indicative of government interest to cooperate internationally in R&D—have no associated budget authority. Nor is there a system in place to link international S&T agreements with actual spending on cooperative R&D. According to a study by the Rand Corporation, the U.S. government spent $3.3 billion on R&D projects involving international cooperation in FY 1995 (which may or may not have been associated with international S&T agreements) and an additional $1.5 billion on non-R&D activities associated with international S&T agreements (Wagner 1997).

[52]See also Poterba (1997) for a discussion of international elements of corporate R&D tax policies.

[53]See OECD (1993 and 1998c) Megascience Forum publications for a concise summary of the history, concepts, and issues behind mega-projects and megascience activities. Additionally, Georghiou (1998) provides a thorough discussion on current global facilities in big science and the emergence of global cooperative programs among governments.